ſouth, ſo often as the above mentioned circumſtances concur, though with ſome interruption from the irregular diſpoſition of the conducting vapors; and may not this occaſion thoſe gleams and ſtreams with which this phenomenon is uſually attended?

N° VIII.

Theory of Water Spouts, by ANDREW OLIVER, *Eſquire, of Salem in the State of Maſſachuſetts.*

IN my laſt I took the liberty to communicate to the Philoſophical Society a Theory of *Lightening* and *Thunder Storms*, which was ſuggeſted to my mind upon the peruſal of doctor *Prieſtley's hiſtory of electricity*. In the inveſtigation of which theory, while I was endeavouring to account for the exhibitions of thoſe phenomena upon the ocean, at great diſtances from the land, ſome thoughts naturally occurred relative to the *water ſpout;* a phenomenon as curious perhaps as any one in nature, and which can rarely take place but at ſea.

WATER SPOUTS have by ſome been ſuppoſed to be merely electrical in their origin; particularly by ſignior *Beccaria*, (*Prieſtley*'s hiſt. of elect. p. 355, 356) who ſeems to have ſupported his hypotheſis by ſome experiments. But as ſeveral ſucceſſive phenomena are neceſſary to conſtitute a complete water ſpout, (ſome of which undoubtedly depend upon the electric principle) if we attend to the moſt authentic deſcriptions of theſe ſpouts, through their various ſtages, from their firſt exhibition to their total diſſipation, we ſhall be obliged to have recourſe to ſome other principle, in order to obtain a complete ſolution. I ſhall therefore, *firſt*, deſcribe theſe phenomena according to the beſt obſervations I have met with; and *then*, endeavour to give

give a general philoſophical ſolution of them. But I muſt here obſerve, that the following deſcriptions are all taken from the accounts of mariners, who are indeed the only perſons that have opportunities of viewing them; but, unfortunately for the cauſe of philoſophy, do not uſually obſerve them with that circumſtantial accuracy, reſpecting the previous and ſubſequent ſtates of the atmoſphere, which may be neceſſary to found a complete phyſical ſolution upon; nor with any view to that end, as it is foreign to their main buſineſs, trade and commerce. But as ſuch accounts are the beſt I have met with even in the Tranſactions of the Royal Society down to 1744, lower than which I have not ſeen them; from ſuch I ſhall endeavour to draw the beſt concluſion which the nature of the evidence will juſtify.

The moſt intelligent and beautiful account of a water ſpout that I ever met with, is in the abridgment of the Phil. Tranſ. vol. VIII, by *Martin*, pa. 655, as it was obſerved by Mr. *Joſeph Harris*, May 21, 1732, about ſunſet, lat. 32° 30′ N. long. 9° E. from cape Florida; which I ſhall here tranſcribe.

" When firſt we ſaw the ſpout (ſays he) it was whole " and entire, and much of the ſhape and proportion of a " ſpeaking trumpet; the ſmall end being downwards, and " reaching to the ſea, and the big end terminated in a black " thick cloud. The ſpout itſelf was very black, and the " more ſo the higher up. It ſeemed to be exactly perpen- " dicular to the horizon, and its ſides perfectly ſmooth, " without the leaſt ruggedneſs. Where it fell the ſpray " of the ſea roſe to a conſiderable height, which made " ſomewhat the appearance of a great ſmoke. From the " firſt time we ſaw it, it continued whole about a minute, " and till it was quite diſſipated about three minutes. It " began to waſte from below, and ſo gradually up, while " the upper part remained entire, without any viſible al- " teration, till at laſt it ended in the black cloud above.

" Upon

" Upon which there ſeemed to fall a very heavy rain in " that neighbourhood. There was but little wind, and " the ſky elſewhere was pretty ſerene——"

In other accounts contained in the Philoſophical Tranſactions, theſe phenomena are deſcribed as having the appearance of a ſword pointing downwards, ſometimes perpendicularly ſometimes obliquely towards a column of water or froth, which ſeems to riſe out of the ſea to meet it, attended with a violent ebullition or perturbation at the ſurface. Again in others the appearance is compared to ſmoke aſcending viſibly as through the funnel of a chimney, either directly, or with a ſpiral motion, which according to the fancies of ſome reſembles the aſcent of water in the ſcrew of *Archimedes;* by ſuppoſing ſomething ſimilar to which in the atmoſphere, they have endeavoured to account for the riſe of the water from the ſea in a water-ſpout. To which I would add, that, from the relations of ſome perſons who uſe the ſea, with whom I have converſed upon the ſubject, I find that it is no uncommon thing, during a calm below, and a ſerene ſky above, to obſerve at the diſtance of two or three leagues a ſmall cloud hovering in the air, from whence the commencing ſpout ſeems to dart downward to the ſea, upon which the uſual phenomena take place in their order. I have alſo been informed (and to information I muſt truſt, having never been at ſea) that it is common during theſe appearances for ſhips to ſail, even within hail of each other, with different winds; and within the limits of the ſame viſible horizon, with contrary winds: And laſtly, that the riſe and progreſs of this phenomenon is ſometimes ſo rapid, that, even in a ſerene ſky, a few minutes will be ſufficient to generate a cloud from one of theſe ſpouts, and to diſcharge from thence a heavy ſhower of rain.

Before I proceed to attempt a philoſophical ſolution of theſe curious productions of nature, in which the two principal fluids of our globe, air and water, are largely concerned;

concerned; it may be neceſſary to make ſome obſervations upon the nature and properties of fluids in general, as ſuch.

1. No fluid can be at reſt unleſs every part of it reſpectively be acted upon by an equal force or preſſure in every direction, till when its ſeveral parts will neceſſarily recede from the greater preſſure towards the leſſer, nor can an equilibrium take place.

2. If two or more fluids of different natures and denſities come together, ſuch as quickſilver, water, oil and air, which will not mix; they will take their places according to their ſpecific gravities, the denſeſt remaining at the bottom.

3. If a veſſel be filled with either of theſe fluids, and a denſer be admitted into it, the latter will expel, and take place of the former.

4. If an empty cylindrical ſpace be ſurrounded on all ſides by a fluid, which is excluded by ſome reſiſting ſurface terminating that ſpace, the fluid will neceſſarily, upon the ſudden removal of the obſtacle, immediately flow in from every ſide towards the center of the void; and as it flows inwards the parts next ſurrounding this ſpace will thereby be crowded together, and force each other upwards, till at length when cloſed, the fluid will by its aſcent have formed a column directly over the middle of the ſpace, to a height proportionable to the united force of the converging currents. This muſt be the caſe with every fluid thus flowing into a vacuum; and in a leſſer degree when a denſer fluid in a ſimilar ſituation ſupplants a rarer: And the greater the difference of the denſities of the two fluids might be, the more conſpicuous would be the effect.

This reaſoning may be illuſtrated, and the concluſions exemplified by facts which muſt have occurred to the obſervation of every one. Do we not obſerve when a ſhower of hail, or rain in large drops, falls upon the ſurface of ſtagnant water, that the water riſes wherever they fall, like ſo many little inverted icicles, which again inſtantly

inſtantly ſubſide? The cauſe of which undoubtedly is, that theſe drops, or hail-ſtones, deſcending from a great height in the atmoſphere, acquire ſeverally ſuch a momentum in their fall as to plunge through the ſurface to a proportional depth, driving the ſuperficial water back on every ſide, and leaving a momentary vacuum behind them; not indeed a pure vacuum, but ſuch, relative to the ſurrounding fluid, which immediately returns to fill up the chaſm, and, as it cloſes, gathers and riſes in the little columns above deſcribed. When a large round ſtone, or any other heavy body plunges, the effect is proportionably greater.

5. Let us, for argument's ſake, ſuppoſe the atmoſphere over any certain circular tract of ocean of ſome miles in diameter, to be for a moment annihilated, the ſpace it occupied before being reduced to a pure vacuum: The ſurrounding atmoſphere, when at liberty, would ruſh in from every quarter towards the centre, where the converging currents would immenſely croud each other, and force up a vaſt quantity of air through a very narrow funnel, contracted below by the united preſſure of thoſe currents from all ſides, into the higher regions; which funnel, as the denſity of the air leſſens according to its height, and the ſurrounding preſſure which contracts it muſt decreaſe nearly in the ſame proportion, would more and more diverge and expand the higher it roſe above the ſurface of the ſea. This would be attended with a moſt furious blaſt of wind up to, and far above the top of the atmoſphere. In like manner,

6. If inſtead of a pure vacuum, or a total annihilation of ſuch part of the atmoſphere, we ſuppoſe the ſame to become, by any means whatever, ſpecifically lihgter than the ſurrounding regions, the effect would be the ſame as above, in kind, though not in degree; the denſer air flowing in, but with leſs rapidity, from all quarters without, expelling the lighter and ſupplying its place, as in article four; upon which alſo a large quantity of this confluent air, for the

ſame reaſon, would be driven up with violence through a like narrow vent, yet not with the ſame impetuoſity, nor to the ſame height as if forced through this funnel into a pure vacuum.

That the atmoſphere over large tracts of ſea or land may thus become ſpecifically lighter than that over the ſurrounding regions, will be evident, if we conſider, 1. That heat has a natural tendency to rarefy and expand the air upon which it acts. 2. That the atmoſphere over our heads does not conſiſt of mere elementary air, but is an univerſal receptacle of all the heterogeneous vapors and effluvia that are perpetually exhaling from every ſubſtance that exiſts upon the face of the earth, whether animal, vegetable or mineral. 3. That, by the caſual diſpoſition of theſe vapors and effluvia in the atmoſphere, the air, which is, of itſelf, naturally enough diſpoſed to acquire heat from the paſſage of the ſun's rays through it, may become more diſpoſed to imbibe and retain that heat, in one region, than in another in its neighbourhood; which, from the intervention of clouds, or from its purity and freedom from thoſe ſteams and vapors with which the former is charged, may, in a great degree, retain its natural coolneſs and denſity, while the other becomes heated, rarefied and expanded, and is thereby rendered ſpecifically lighter.

That theſe different affections of the atmoſphere *actually* take place, and diſpoſe the air, at one time and in one place, even in the ſame ſeaſons of the year, to imbibe and retain the heat excited by the ſun's rays, more than at another, is not a matter of mere conjecture; but, whatever the cauſe may be, is notorious to all perſons of obſervation.

Theſe things being premiſed, I beg leave to obſerve further, that ſome parts of the ocean are liable to long and extenſive calms, during the continuance of which the heat is ſcarcely tolerable. Where theſe take place the air muſt neceſſarily undergo proportional changes in its denſity and

electric

*electric capacity**; and when heated and rarefied to ſome certain degree will give way, as obſerved above, to the denſer air, now proportionably diſpoſed to flow in from all quarters without the limits of the calm.

When once this ſtagnated air, eſpecially if of any great extent, becomes ſpecifically lighter than the ſurrounding air, and ſufficiently rare to be ſupplanted by it; the latter will, of courſe, ſet it from every ſide in horizontal currents; which will flow, either directly, or obliquely, towards one point, in or near the centre of the becalmed region aforeſaid; the obliquities of which currents will depend upon the directions and velocities of the winds, or currents of air which might previouſly have taken place in the ſurrounding regions. When theſe currents arrive at the centre of their mutual convergency, all the ſtagnated and rarefied air which was before incumbent upon the calm ſurface of the ſea, will have been expelled and forced higher up into the atmoſphere; upon which theſe currents, by their mutual concourſe in one place, will exceſſively croud each other, as obſerved above, wherever it happens, driving the central air upwards with a violent blaſt; which, ſhould the currents ſet in obliquely, and ſo converge with a ſpiral motion towards the centre of their mutual concourſe, would aſcend as through the ſcrew of Archimedes, or the worm of a cork-ſcrew, to both of which navigators have likened theſe ſpouts: Otherwiſe it would riſe through a ſtrait, narrow funnel, as in articles five and ſix above; which if filled with any opaque matter would become viſible, and at a diſtance would reſemble a ſpeaking trumpet with the ſmall end downwards, in which form the water ſpout frequently appears. In the former caſe a whirlwind round about the centre would undoubtedly be the conſequence; and in either, a water ſpout would probably be produced†.

* See Theory of Lightening, &c. page 81.

† We ſhall in the ſequel ſee abundant reaſon to conclude with doctor *Franklin* and others, that water ſpouts at ſea and whirlwinds on the land (ſome ſpecies of them at leaſt) are produced by the ſame cauſes.

For the preſſure of the atmoſphere is taken off from that part of the ſurface of the ſea, which is directly under the funnel through which the air is driven up; whereas the ſurrounding ſurface is at the ſame time uncommonly preſſed, from the confluence of the currents from all quarters*, whereby the water muſt neceſſarily be forced up to a certain height, proportional to the ſurrounding preſſure, through the ſame funnel with the air itſelf, nor is this all, for in their aſcent the air and water become confuſedly mixed together, whereby the latter is broken and attenuated into the fineſt globules and particles, as when one forcibly blows water out of his mouth; and from this mixture of the two fluids doubtleſs ariſes that opacity which renders the ſpout viſible.

This opaque column of air and water, together with the paſſage through which it aſcends, will expand as it riſes, in proportion as the compreſſure diminiſhes; and, to ſpectators at too great a diſtance to diſcern the narrow ſtem next the water, will reſemble a ſword, or acute cone pointing downwards from a ſmall cloud; to which they are frequently likened. But that they do at the ſame time communicate with the ſea is evident from the perturbation of the water directly under them, which ſometimes boils and foams at a great rate. This is uſually the firſt appearance of one of theſe ſpouts, the duration of which is either longer or ſhorter, and the ſubſequent phenomena more or leſs conſiderable, according to the extent of the cauſe, and the mode of its operation.

The water being thus raiſed from the ſea, and forced irreſiſtably upwards in the fineſt globules by the protruding air, arrives at length at the warm electrical air† lately expelled,

* In the abridgment of Philoſophical Tranſactions, vol. II. (by Eames and Martin) page 61, at the bottom, it appears, that the meeting of two contrary currents of air or contrary winds, raiſes the mercury in the barometer near the place where it happens, which indicates an increaſe of the preſſure of the atmoſphere upon the ſurface of the earth or ſea. How much more then muſt that preſſure be increaſed, from a general confluence of the air from all quarters towards one ſpot?

† See Theory of Lightening, &c. page 90.

expelled, which was previouſly incumbent upon the calm ſurface beneath; the electric attraction of which probably aſſiſts the further aſcent of theſe particles after the firſt fury of the blaſt is ſpent. There it undergoes another operation being converted into vapor, whereby it is wholly diſcharged of the marine ſalts it carried up with it*; which are now left to ſhift for themſelves, together with innumerable other heterogeneous corpuſcles which ſucceſſively float in the atmoſphere, and which in due time, become ſeverally ſubſervient to many wiſe purpoſes in the œconomy of nature. Theſe vapors will then be greedily attached by the craving particles of this air, now deficient of its natural quantity of electric matter†, and form a denſe cloud, in like manner as thunder clouds are formed over the land; but with much greater expedition, as the ſupply of vapors is more ſudden. This cloud will then be ready in a ſhort time to diſcharge a ſhower of freſh water upon the ſea from whence it roſe, and may be attended with thunder and lightening, or not, as the air in which the cloud was formed was more or leſs electrical, or the cloud extenſive.

A previous calm may not be *neceſſary* to the production of theſe phenomena, and indeed they frequently happen without one: But, upon the ſame principle, if it be calmer where they are produced, or the ſtate of the atmoſphere there be ſuch as to diſpoſe it to acquire and retain the heat acquired from the ſun's rays, more than in the ſurrounding regions, which, as we have ſeen above, may be the caſe, the effects may be the ſame in kind, though perhaps not in degree; the moſt perfect water ſpouts probably riſing from whence there has previouſly been a dead calm, or nearly ſuch, for the foregoing reaſons.

If

* The water carried up in one of theſe ſpouts is undoubtedly ſalt when it firſt riſes from the ſea, as it aſcends in great quantities, and in a very denſe column; but it is always freſh when it deſcends again in a ſhower: It muſt therefore in the mean time have gone through a compleat natural diſtillation.

† Theory of Lightening, &c. page 92.

If there be any wind at the time of the phenomenon, the aerial funnel through which the water aſcends, inſtead of being perpendicular to the horizon, as it would be in a calm, might incline more or leſs to it, in proportion to the ſtrength or weakneſs of the prevailing current of air: Or, inſtead of continuing in one ſpot, it might have a progreſſive motion over the ſurface of the ſea, in the direction of the general current; both of which circumſtances frequently take place. In either caſe it is natural to ſuppoſe, that both air and water would aſcend ſpirally, as through the worm of a ſcrew, every current which ſets in towards the centre receiving an oblique bias from the prevailing current.

It ſometimes happens, that after the ſubſiding of a ſpout, it is ſucceeded by a ſecond, and that by a third, either in the ſame place, or at no great diſtance from it. But this alſo is analogous to what we obſerve upon the plunging of heavy bodies out of air into water. For, after the firſt ſubſiding of the ſmall column of water which is occaſioned by it, and is above reſembled to an icicle, the water again riſes and ſubſides as at firſt, though not in the ſame degree, as may be concluded from thoſe fainter concentric circles which expand from the ſame centre after the ſubſidence of the firſt column. The ſame thing which here takes place in water, may alſo take place in air, under ſimilar circumſtances.

Since writing the foregoing, while I was endeavouring to contrive ſome experiment to illuſtrate the ſubject, a very ſimple one was ſuggeſted to my mind, the ſucceſs of which I think demonſtrates the truth of the hypotheſis introduced above to account for the firſt aſcent of the water in the ſpout; the event being preciſely the ſame as was expected before hand, and as ought to have taken place upon the principles above advanced.

EXPERIMENT.

In a ſtiff paper card I made a hole juſt big enough to inſert a gooſe quill ſo as that it might be fixed perpendicularly

cularly to the plane of the card: After cutting the quill off ſquare at both ends and fixing it, I laid the card upon the mouth of a wine glaſs, filled with water to within one fifth or ſixth part of an inch from the lower orifice of the quill; then applying my mouth to the upper part, I drew out the air in the quill by a ſtrong ſuction, and in one draught of my breath drew in about a ſpoonful of the water; this by ſtronger ſuctions I was able to repeat again and again, the quill remaining as before. The water, as I expected, did not aſcend to the mouth in a ſtream, as it would have done had the quill reached below the ſurface; but broken and confuſedly mixed with the air which aſcended with it; as is above ſuppoſed to be the caſe in the aſcent of water in a ſpout at ſea.

In this experiment the ſuction occaſioned a vacuum, or at leaſt a great rarefaction of the air, within and directly under the quill; the ſurrounding air of courſe flowed in from every quarter to ſupply it, ruſhing up into the quill, and through it to the mouth; the preſſure of the atmoſphere being thereby taken off from the ſurface of the water immediately under the orifice, while the preſſure upon the ſurrounding ſurface remained, and was probably increaſed, the water was forced up together with the air as above notwithſtanding the quill had no manner of communication with the water. If the ſuction be made very ſtrong, and the quill be fixed at the diſtance of a quarter of an inch or more from the water, a conſiderable agitation and ebullition takes place in the water under it, ſimilar to that obſerved in moſt natural water ſpouts, and the paſſage of the water from the ſurface to the quill becomes very viſible.

It was hinted in a preceding note, that water ſpouts at ſea and whirlwinds at land, ſome ſpecies of them at leaſt, ariſe from the ſame cauſe, how different ſoever their apparent effects may be. This I think is made ſufficiently evident from the obſervations of a couple of land ſpouts at

Hatfield

Hatfield in *Yorkſhire*, by Mr. *Abr. de la Pryme**, whoſe accounts of them I ſhall here tranſcribe, as the Tranſactions of the Royal Society are in the hands of but few among us, and as the facts related by him tend ſtrongly to confirm the preſent theory, however his concluſions from them may differ from it.

"On the 15th of Auguſt, 1687, (ſays he) appeared a "ſpout in the air at *Hatfield* in *Yorkſhire*; it was about a "mile off coming directly to the place where I was; I "took my proſpective glaſſes to obſerve it as well as I "could.

"The ſeaſon was very dry, the weather *extreme hot*, "and the air very cloudy; the wind aloft, and pretty "ſtrong, and (which is remarkable) blowing out of ſeve-"ral quarters at the ſame time, and filling the air here-"abouts with mighty thick and black clouds, layer upon "layer; the wind thus blowing ſoon created a great *vor-"tex*, *gyration* and *whirling* among the clouds; the cen-"tre of which every now and then dropt down in the "ſhape of a thick, long, black pipe, commonly called a "ſpout; in which I could diſtinctly view a motion like "that of a ſcrew, continually drawing upwards, and ſcrew-"ing up (as it were) whatever it touched. In its progreſs "it moved ſlowly over a hedge-row and grove of young "trees which it made to bend like hazle wands, in a cir-"cular motion; then going forward to a great barn it "twitched off in a minute all the thatch, and filled the "whole air therewith. Coming to a very great oak tree, "it made it bend like the foregoing trees, and broke off "one of the greateſt and ſtrongeſt branches that would "not yield to its fury, and twiſting it about, flung it to a "very conſiderable diſtance off; then coming to the place "where I ſtood, within three hundred yards of me, I be-"held this odd phenomenon, and found that it proceeded "from nothing but a *gyration of the clouds by contrary winds*

* Abridgment of Philoſophical Tranſactions, vol. IV. by Jones, page 106, 107.

" *winds meeting in a point or centre;* and where the great-
" eſt condenſation and gravitation was, falling down into
" a pipe or great tube (ſomething like the *cochlea Archi-*
" *medis*) and that in its working or whirling motion, ei-
" ther ſucks up water, or deſtroys ſhips, &c. Having tra-
" velled about a quarter of a mile farther, it diſſolved by
" the prevalency of the wind that came out of the eaſt."

The account of the other is as follows, viz. " I have
" ſeen another ſpout in the ſame place, which very much
" confirms me in my notion of the origin and nature of
" them.—The 21ſt of June, 1702, was *pretty warm;* on
" the afternoon of which day, about two of the clock, *no*
" *wind ſtirring below* though it was ſomewhat great in the
" air, the clouds began to be mightily agitated and driven
" together; whereupon they became very black, and were
" (moſt viſibly) *hurried round*, from whence proceeded a
" moſt audible whirling noiſe, like that commonly heard
" in a mill. After a while, a long tube or ſpout came
" down from the centre of the congregated clouds, in
" which was a ſwift *ſpiral motion* like that of a ſcrew, or
" the *cochlea Archimedis* when it is in motion, by which
" ſpiral nature and ſwift turning, water aſcends up into
" the one as well as into the other. It travelled ſlowly
" from weſt to north-eaſt, broke down a great oak tree or
" two, frighted ſome out of the fields, and made others
" lie down flat upon their bellies, to ſave being whirled
" about and killed by it, as they ſaw many jackdaws to
" be, that were ſuddenly caught up, carried out of ſight,
" and then caſt a great way amongſt the corn; at laſt it
" paſſed over the town of *Hatfield*, to the great terror of
" the inhabitants, filling the whole air with the thatch that
" it plucked off from ſome of the houſes; then touching
" upon a corner of the church, it tore up ſeveral ſheets of
" lead, and rolled them ſtrangely together; ſoon after
" which it diſſolved and vaniſhed without doing any fur-
" ther miſchief.

" By all the obſervations that I could make of this, and " the former, I found that had they been at ſea and joined " to the ſurface thereof, they would have carried a vaſt " quantity of water up into the clouds, and the tubes would " then have become much more ſtrong and opaque than " they were, and have continued much longer.

" It is commonly ſaid that at ſea the water collects and " bubbles up a foot or two high under theſe ſpouts before " that they be joined: But the miſtake lies in the pellu- " cidity and fineneſs of thoſe pipes, which do moſt certain- " ly touch the ſurface of the ſea before that any conſider- " able motion be made in it, and that, when the pipe be- " gins to fill with water, it then becomes opaque and " viſible."

I ſhall here make a remark or two upon the above cited author's mode of expreſſion in the foregoing accounts, which is evidently adapted to a preconceived idea of the *cochlea Archimedis*, by ſuppoſing ſomething ſimilar to which, as taking place in our atmoſphere, he is not alone in endeavouring to account for theſe phenomena. In conformity to this idea he ſpeaks of the ſpout as *drawing upwards*, and *ſcrewing up* whatever it touched; and ſuppoſes that by its *ſpiral motion* and *ſwift turning*, water aſcends in it as in the *ſcrew of Archimedes*. But this hypotheſis, however ſpecious, has been long ſince exploded as unphiloſophical.

Mr. *de la Pryme* mentions the appearance of a long black pipe which now and then dropped down from the centre of the gyrating clouds; in which pipe he diſtinctly viewed a motion like that of a ſcrew; and as ſuch he ſeems to have ſuppoſed it acted, viz. either in the manner of a cork-ſcrew upon ſolids, or as the *cochlea Archimedis* upon fluids, drawing them up into the atmoſphere. But as he himſelf afterwards, when applying his obſervations to a ſpout at ſea, very juſtly concludes that the pellucidity and fineneſs of theſe pipes over the water render them inviſible below,

" notwithſtanding

" notwithſtanding (as he conceives) that the pipes do moſt " certainly touch the ſurface of the ſea before any conſider- " able motion be made in it, and that they are then rendered " opaque and viſible when they begin to fill with water;" might he not with equal reaſon have ſuppoſed that thoſe aerial pipes which he obſerved over the land were alſo continued from the clouds down to the ſurface of the earth, as from their effects below, one would naturally conclude they were, and that they were pellucid and inviſible ſo long as they contained nothing but air; but that " every " now and then," when they met with any ſubſtances which might perchance paſs within the compaſs of their gyration, or which they could eaſily carry up; ſuch as detached parts of the broken clouds; water from ſtagnant ponds, brooks and rivers, hay, ſtubble, thatch, duſt, &c. they then become opaque and viſible, and that they appeared to dart downwards by a kind of optical deception? For upon the foregoing principles theſe pipes of air muſt neceſſarily be broadeſt above, as we have already ſeen, and terminate in a narrow ſtem below, the broadeſt part being, at a diſtance, firſt viſible, and the ſhank ſeemingly tapering downwards to a point. It is however certain from the effects of the above mentioned ſpouts, that, whatever the appearances were *aloft*, they were all occaſioned by the ruſhing of the air upwards through a narrow paſſage, that was contracted *below*, by the concourſe and preſſure of the oppoſite currents of that fluid, and dilated above from the diminution of that preſſure.

I have reſerved for this place an account of a curious ſpout which made its appearance *anno* 1694, not at ſea, but in the harbour of *Topſham**, and at low water; which paſſed with a ſlow progreſſive motion over both land and water; acting as a complete water ſpout over the latter, and as a whirlwind upon the former: For when it paſſed over the channel of the river, it threw up the water in a denſe

* Lowthorp's Abridgm. Phil. Tranſ. vol. II. page 104.

ſtream, as if it had been impelled through the hoſe of a fire engine, and the ſtream accordingly ended in a thick miſt, reſembling a dark ſmoke; the ſurface of the water, round about the ſpot from whence it roſe, being greatly agitated, as is uſual in thoſe phenomena. In its courſe it met with the hull of a new ſhip of about one hundred tons, which was much ſhaken by it, but received no hurt. In paſſing over the flats it took hold of a boat which was faſtened to an anchor, whirled both boat and anchor to ſome height in the air, and rent the boat "from the *head* "to the *keel*." When it reached the ſhore it lifted up another boat about ſix feet from the ground, letting it fall again upſidedown; and had a ſtrange effect upon a parcel of planks, ſome of which were raiſed up perpendicularly, and ſtood upon their ends while it paſſed along; and in its further progreſs it was attended with the uſual effects of a whirlwind, ſuch as ſtripping off, not only thatch, but ſheets of lead from the tops of houſes, and tearing off the limbs of trees. This account may tend to confirm the theory here offered, as it proves to a demonſtration, that the water ſpout therein deſcribed, was occaſioned by a previous whirlwind in the atmoſphere; which whirlwind was alſo occaſioned by the ruſhing of a large quantity of air, upwards, from all quarters near the ſurface of the earth, through a very contracted aerial paſſage, towards the top of the atmoſphere; the narrowneſs of which paſſage, as determinable from the effects obſerved in its progreſs, ſhews it to have been compreſſed upon all ſides by a general conflux of oppoſite currents of air; as the ruſhing of the air through it with ſuch violence from beneath, does, that the denſity of the fluid and the compreſſive force of the currents were greateſt there. The aſcending air carried up the water with it through the ſame paſſage; not by any mechanical operation upon it, like the action of a ſcrew of any kind; but, merely, by taking off the preſſure of the atmoſphere from the ſurface of the water directly under it;

it; whence the water muſt neceſſarily aſcend, as in any common hydraulic machine; and that with a force proportional to the preſſure of the atmoſphere upon the ſurrounding ſurface, now greatly increaſed by the confluence of thoſe currents.

Before I cloſe this ſubject, I ſhall juſt mention, without making any remarks, the effects which a whirlwind had amongſt a number of ſhocks of corn at *Warrington* in *Northamptonſhire*, Auguſt 1ſt, 1694; out of which from eighty to a hundred ſhocks were carried up into the air, a great part of them out of ſight; theſe when the fury of the blaſt was ſpent, fell down again at the diſtance of ſome miles from their own field. The account of this whirlwind immediately precedes the article laſt quoted from the *Philoſophical Tranſactions*. Should the foregoing theory be adjudged tenable, it will render very credible thoſe ſtrange accounts which we have ſometimes had, of its raining tadpoles and frogs, which have been found upon the tops of houſes after a ſhower; and even ſmall fiſhes, a ſhower of which fell at *Cranſtead* near *Wrotham* in *Kent*, *anno* 1696, on the Wedneſday before Eaſter (Lowthorp's abridgement of Philoſophical Tranſactions, vol. II. page 144.) For ſhould one of thoſe aerial pipes paſs over a frog pond, or the ſhallow parts of a fiſh pond, the ſame natural cauſe which in a ſpout at ſea, would carry up the water from the ocean, would alſo carry up the water from the ponds aforeſaid, together with the contents; whether tadpoles, frogs or fiſhes: Theſe muſt deſcend again ſomewhere; and wherever they fell, a ſhower of fiſhes, frogs or tadpoles, would be the conſequence.

Experiments